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[Title of the Invention] Transfer Unit

[Abstract]

[Problem to be Solved]

To provide a transfer unit which is capable of suppressing swirling of dust and performing high-speed transfer by providing an arrangement in which smooth passage over a dead point is performed with a link mechanism, and also capable of turning over an object to be transferred with a simple method even when a layout of a destination apparatus requires a slewing motion in the transfer.

[Solution]

The transfer unit comprises: a main lever 1 having fulcrums at both ends and at substantially a middle position thereof, the fulcrum at one end being pivotally attached to a moving body 4 that moves on a straight line, and the fulcrum at the other end being pivotally attached to a transfer part 3; a sub-lever 2 having approximately one half a length of the main lever 1 and having fulcrums at both ends thereof, the fulcrum at one end being pivotally attached to a frame 6 located on a line extending from a straight line along which the moving body 4 moves, and the fulcrum at the other end being pivotally attached to substantially a middle position of the main lever 1; two sets of parallel link bodies for connecting between the frame 6 and the transfer part 3, the parallel link bodies each having a parallelogrammic shape,

and the parallel link bodies comprising the main lever 1, the sub-lever 2, two parallel links L1 and L3, one of which is parallel to the main lever 1 and another of which is parallel to the sub-lever 2, and a parallel link L2 connecting them; and a sub-lever drive unit 7 functioning as a drive unit of the parallel link bodies.

[Claims for the Patent]

[Claim 1]

A transfer unit characterized by comprising:

a main lever having fulcrums at both ends and at substantially a middle position thereof, the fulcrum at one end being pivotally attached to a moving body that moves on a straight line, and the fulcrum at the other end being pivotally attached to a transfer part;

a sub-lever having approximately one half a length of said main lever and having fulcrums at both ends thereof, the fulcrum at one end being pivotally attached to a frame located on a line extending from a straight line along which said moving body moves, and the fulcrum at the other end being pivotally attached to substantially the middle position of said main lever;

two sets of parallel link bodies for connecting between said frame and the transfer part, the parallel link bodies each having a parallelogrammic shape, and the parallel link bodies comprising said main lever, said sub-lever, two parallel links, one of which is parallel to said main lever and another of which is parallel to said sub-lever, and a parallel link connecting them; and

a drive unit of said parallel link bodies.

[Claim 2]

The transfer unit according to claim 1, characterized by further comprising a shape control mechanism for controlling

the shapes of said parallel link bodies when said parallel link bodies pass a dead point.

[Claim 3]

The transfer unit according to claim 2, characterized in that said shape control mechanism selectively keeps or not keep the shapes of said parallel link bodies.

[Claim 4]

The transfer unit according to claim 2 or 3, characterized in that said shape control mechanism comprises a electromagnet and a permanent magnet which is located at a position relative to said electromagnet.

[Claim 5]

The transfer unit according to claim 1, 2, 3 or 4, characterized by further comprising a lifting unit for lifting up/down the entire frame including said transfer part.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a transfer unit, and in particular, to a transfer unit, which enables high-speed and accurate transfer of large substrates such as for LCDs transferred at high speed in a clean room, while suppressing dust from being swirled.

[0002]

[Conventional Art]

In transferring large substrates such as for LCDs in a clean room, robots such as one shown in Figures 5 and 6

have generally been used as transfer units. Such a robot employs a horizontal articulated manipulator provided with a pickup fork at an end thereof, or employs a telescopic arm. In either of the systems, it is so arranged that a main body H is provided with a lifting mechanism and a slewing mechanism to transfer an LCD, for example, with left and right movement, in Figure 5, of a transfer part 3 by combining drawing/withdrawing, lifting up/down and slewing motions of the fork or the arm.

[0003]

[Problems to be Solved by the Invention]

The conventional transfer units, or those which employ horizontal articulated manipulators, in particular, have each been arranged to utilize a gear, a belt, a rope or the like in order to have a link mechanism A of the horizontal articulated manipulator avoided passing a dead point. In a clean room, the end of a pickup fork or a telescopic arm is required to be inserted into a narrow space in order to transfer thin-plate objects to be transferred, such as glass substrates for LCDs or wafers for semiconductor devices. For this reason, the end of a pickup fork or a telescopic arm has been formed into a shape of a thin cantilever, and the link mechanism A or a frame of the horizontal articulated manipulator supporting the pickup fork or the telescopic arm has been located outside the pickup fork or the telescopic arm.

[0004]

The conventional transfer units therefore have raised the following problems.

1. The link mechanism A or the frame of a horizontal articulated manipulator for supporting the end of a pickup fork or a telescopic arm requires a predetermined dimension heightwise to enhance rigidity, and has to be arranged outside the pickup fork or the telescopic arm. Therefore, a slewing motion has been absolutely necessary in transferring an object to be transferred. The slewing motion, however, requires time and limits high-speed transfer.

2. A space sufficient for a maximum radius of an object to be transferred and of the transfer unit has to be ensured at the time of the slewing motion, leading to the limitation in the layout of an entire factory.

3. In case a horizontal articulated manipulator is used in a transfer unit, since a link mechanism has a dead point, such an item as a gear, a belt or a rope has to be used to avoid the dead point. Use of such an item, however, involves swirling of dust, oil supply, elongation or the like, causing difficulty in use, for example, in maintenance, stopping accuracy and durability, in a clean room where high-accuracy operation is required.

4. In case a telescopic arm is used in a transfer unit, use of multistage structure may enable transfer of an object to be transferred without a slewing motion. This, however, makes the structure of the transfer unit complicated and causes difficulty in completely sealing a drive unit of the

transfer unit. Accordingly, there is a limitation in keeping cleanliness and there is difficulty in the maintenance from the viewpoint of oil supply and reliability.

[0005]

The present invention has been made in view of the problems of the conventional transfer units as described above, and has as its object to provide a transfer unit which is capable of suppressing swirling of dust and performing high-speed transfer by providing an arrangement in which the slewing motion with a gear, a belt, a rope or the like is eliminated, and smooth passage over a dead point is performed with a link mechanism, and also capable of turning over an object to be transferred with a simple method even when a layout of a destination apparatus requires a slewing motion in the transfer.

[0006]

[Means for Solving the Problems]

In order to achieve the object provided above, a transfer unit of the present invention is characterized by comprising: a main lever having fulcrums at both ends and at substantially a middle position thereof, the fulcrum at one end being pivotally attached to a moving body that moves on a straight line, and the fulcrum at the other end being pivotally attached to a transfer part; a sub-lever having approximately one half a length of said main lever and having fulcrums at both ends thereof, the fulcrum at one end being pivotally attached to a frame located on a line extending from a straight line

along which said moving body moves, and the fulcrum at the other end being pivotally attached to substantially the middle position of said main lever; two sets of parallel link bodies for connecting between said frame and the transfer part, the parallel link bodies each having a parallelogrammic shape, and the parallel link bodies comprising said main lever, said sub-lever, two parallel links, one of which is parallel to said main lever and another of which is parallel to said sub-lever, and a parallel link connecting them; and a drive unit of said parallel link bodies.

[0007]

In this transfer unit, since an arrangement is made such that an object to be transferred is transferred to the other side of the transfer unit without a slewing motion of the transfer unit, transfer time can be reduced. Further, since only the fulcrums in the forms of pins and serving as pivots are moved to transfer points, a high-degree of cleanliness can be maintained. Further, a guide rail located at a center of the transfer unit with no back-and-forth movement can limit source of dust to hardly cause swirling of dust. This can provide an easier measure for cleanliness comparing with the case of a telescopic arm and also can provide a measure for reducing weight and cost. Furthermore, owing to the link mechanism, both ends of the transfer unit are enabled to perform gradual speed up and gradual stoppage in the drawing/withdrawing motion, thereby reducing shock and facilitating high-speed operation. The link mechanism

can also provide a simplified structure, which is advantageous from the viewpoints of duration of life and maintenance.

[0008]

In this regard, the transfer unit can include a shape control mechanism for controlling shapes of parallel link bodies when the parallel link bodies pass the dead point. The shape control mechanism can be adapted to selectively keep or not keep the shapes of the parallel link bodies.

[0009]

Thus, an object to be transferred can be transferred with the transfer part being stably moved horizontally or being moved with a turnover motion.

[0010]

The shape control mechanism can comprise an electromagnet and a permanent magnet which is positioned relative to the electromagnet.

[0011]

Thus, the shape control mechanism can have a structure which is simple, and easy to control with high reliability and no swirling of dust.

[0012]

The transfer unit can comprise a lifting unit for lifting up/down the entire frame including the transfer part.

[0013]

Thus, source of dust is limited and thus swirling of dust is hardly caused, and measures for achieving high cleanliness can be much facilitated.

[0014]

[Embodiments of the Invention]

Hereinafter is described an embodiment of the transfer unit of the present invention with reference to the drawings.

[0015]

Figures 1 to 4 illustrate an embodiment of the transfer unit of the present invention. This transfer unit is configured as described below.

[0016]

A base end side of a main lever 1 having a length suitable for a distance across which an object G to be transferred is transferred, is pivotally attached to a moving body 4 through a pin P7, and a top end side of the main lever 1 is pivotally attached to a transfer part 3 through a pin P1.

[0017]

An arrangement capable of transfer is provided by allowing the object G to be transferred, such as a glass substrate, to be placed on the transfer part 3 by suction force of a suction cup (not shown) as required, for example. Although an H-shaped transfer part 3 is used in the present example, it should be appreciated that the shape is not particularly limited to this, but the shape of the transfer part 3 may have optional shapes, such as a pan shape or a chuck type shape. The transfer part 3 is adapted to be pivotally attached to the main lever 1 at a center position of the transfer part 3 through the pin P1. Also, the transfer part 3 is

adapted to be pivotally attached to an end of the parallel link L1, which is disposed parallel to the main lever 1, through a pin P2, being appropriately distanced from the pin P1 in a direction X perpendicular to a moving direction Y to which the transfer part 3 moves.

[0018]

An arrangement is made such that the moving body 4 is pivotally attached to the base end side of the main lever 1 through the pin P7, and that the moving body 4 is guided by a guide rail 5 so as to be freely moved along the direction X perpendicular to the moving direction Y of the transfer part 3. As the guide rail 5, a linear bearing or a wheel typeone,forexample,canbeused,beingfurnished,asrequired, on its side face with a cable carrier (not shown) for coupling thereto an electric supply line or a control line.

[0019]

The parallel link L1 has a length approximately one half of the main lever 1, and is disposed on the lower side of the main lever 1, so that the both may not interfere with each other while the transfer part 3 is moved in the moving direction Y. The parallel link L1 is also pivotally attached to a parallel link L2 through a pin P3, the parallel link L2 being disposed so as to be parallel to a line connecting between the pins P1 and P2 of the transfer part 3.

[0020]

The parallel link L2 is disposed on the lower side of the parallel link L1, so that the both may not interfere

with each other while the transfer part 3 is moved in the moving direction Y. Further, one end of the parallel link L2 is pivotally attached to substantially a middle position of the main lever 1 through a pin P4, so that the parallel link L2 is positioned on the lower side of the parallel link L1, thereby avoiding interference therebetween again while the transfer part 3 is moved in the moving direction Y. In this way, a parallel link body having a parallelogrammic shape is formed by the pivotally attached main lever 1, the parallel link L1, the parallel link L2 and the transfer part 3 through the pins P1, P2, P3 and P4. The transfer part 3 and the parallel link L2, when moved in the moving direction Y, are thus ensured to maintain parallel positional relation.

[0021]

A parallel link L3 having a length approximately one half of the main lever 1 is pivotally attached to the parallel link L2 through the pin P3. The parallel link L3 is located on the lower side of the parallel link L2 so as to avoid interference during the movement along the moving direction Y. The parallel link L3 is pivotally attached to a frame 6 through a pin P5.

[0022]

A sub-lever 2 is disposed parallel to the parallel link L3 and pivotally attached to substantially a middle position of the main lever 1 through the pin P4. The other end of the sub-lever 2 is pivotally attached to the frame 6 through a pin P6 so as to allow oscillatory movement. Similar to

the parallel link L3, the sub-lever 2 has a length approximately one half of the main lever 1 and is located on the lower side of the parallel link L3 to avoid interference during the movement along the moving direction Y.

[0023]

The pin P5 for pivotally attaching a base end side of the parallel link L3 to the frame 6, and the pin P6 for pivotally attaching a base end side of the sub-lever 2 to the frame 6, are located on a line extending in the moving direction X of the moving body 4. In this way, a parallel link body having a parallelogrammic shape is formed by the parallel link L2, the parallel link L3, the sub-lever 2 and a portion of the frame 6, being linked through the pins P3, P4, P5 and P6. The parallel link L2 and the moving direction X of the moving body 4 are thus ensured to keep parallel positional relation also during the movement of the transfer part 3 in the moving direction Y.

[0024]

The base end side of the sub-lever 2 is fixed to a rotating shaft of a sub-lever drive unit 7 through the pin P6 so as to give oscillatory movement about the pin P6 when the sub-lever drive unit 7 is driven. Thus, the sub-lever drive unit 7 constitutes a drive unit for the parallelogrammic parallel link body formed by the pivotally attached main lever 1, the parallel link L1, the parallel link L2 and the transfer part 3 through the pins P1, P2, P3 and P4, and for the parallelogrammic parallel link body formed by the parallel

link L2, the parallel link L3, the sub-lever 2 and the portion of the frame 6, which are linked by the pins P3, P4, P5 and P6. It should be appreciated that, as the drive unit for the parallel link bodies, such drive units can optionally be employed as one that oscillates the sub-lever 2 about the pin P6, as well as one that oscillates the parallel link L3 about the pin P5, and one that moves the moving body 4 in the direction X perpendicular to the moving direction Y of the transfer part 3.

[0025]

Further, an arrangement is so made that the frame 6 is linked to a lifting unit 8 and enabled to lift up/down together with the transfer part 3, the main lever 1, the sub-lever 2, the parallel links L1, L2 and L3 and the like.

[0026]

To serve as the shape control mechanism for controlling the shapes of the parallel link bodies when the parallel link bodies pass the dead point, the transfer part 3 is attached with a permanent magnet M1 at a position on a line extending from a line connecting the pins P1 and P2, and the frame 6 is attached with an electromagnet E1. The permanent magnet M1 and the electromagnet E1 are ensured to have a relative positional relation therebetween so as to effect with each other when the parallel links L1 and L3 pass the dead point.

[0027]

Further, an electromagnet E2 is attached to an end of the parallel link L2 or onto a line extending from the parallel

link L2, and a permanent magnet M2 is attached onto the parallel link L3. The electromagnet E2 and the permanent magnet M2 are ensured to have a relative positional relation therebetween so as to effect with each other when the parallel links L2 and L3 pass the dead point. In this case, an arrangement is so made that the electromagnets E1 and E2 consist of pairs of coils EC1 and EC2, respectively, as shown in Figure 3 so that the moving directions of the parallel links L1, L2 and L3 can be controlled.

[0028]

The sub-lever drive unit 7 is disposed in the frame 6, so that the parallel link bodies can flex and extend through the sub-lever 2. Also, the guide rail 5 is allowed to laterally project to movably support the moving body 4 while defining the moving direction of the moving body 4. Further, the entire frame 6 is allowed to be lifted up/down by the lifting unit 8.

[0029]

It should be appreciated that the shapes of the main lever 1, the sub-lever 2 and the parallel links L1, L2 and L3 are not limited to the ones shown in the figure, but may have optional shapes, such as a round-bar shape, a piped shape, an H shape or a bent shape. Change of dimensions of the main lever 1, the sub-lever 2 and the parallel links L1, L2 and L3 allows adjustment of transfer points or slewing angles. For this purpose, means for adjusting length, such as an adjusting screw, may be provided, as required, to the

main lever 1, the sub-lever 2 and the parallel links L1, L2 and L3 of the parallel link bodies.

[0030]

As shown in Figure 1, the permanent magnets M1 and M2, and the electromagnets E1 and E2 serving as the shape control mechanism for controlling the shape of the parallel link bodies, may be disposed in various ways, such as horizontal disposition, vertical disposition, sandwiched disposition or circular disposition.

[0031]

Description is now provided on the operation of the transfer unit with reference to Figures 2 to 4. Transfer of the object G to be transferred placed on the transfer part 3 can be carried out by oscillating the sub-lever 2 with the aid of the sub-lever drive unit 7. For example, since the sub-lever 2 has approximately one half the length of the main lever 1, when the sub-lever 2 is oscillated about the pin P6 to have the sub-lever 2 moved from a position shown by a solid line in Figure 2 to a position shown by a broken line, either of triangles formed by connecting the pins P1, P4 and P6, and formed by connecting the pins P4, P6 and P7 results in an isosceles triangle. In this case, the angles made by the main lever 1, the sub-lever 2, the parallellinks,theguiderailandthelikesatisfythefollowing equations:

$2\alpha+\gamma=2\beta+\delta=180°$

$\gamma+\delta=180°$

from which the following equation can be derived:

$\alpha+\beta=90°$

Accordingly, since the pin P7 moves on the linear guide rail 5 together with the moving body, the pin P1 is constantly positioned right angle to the guide rail 5 to resultantly move on a straight line.

[0032]

The main lever 1 is supported on the single-sided guide rail 5, so that the rigidity is enhanced, and that, comparing with a manipulator system, dimension of the cross section of the lever can be reduced to thereby reduce the weight. Thus, the main lever 1 is suitable for miniaturization and high-speed operation. Each of a quadrangle formed by connecting the pins P1, P2, P3 and P4, and a quadrangle formed by connecting the pins P3, P4, P5 and P6 constitutes a parallel link body having a parallelogrammic shape. Therefore, a line connecting the pins P1 and P2 constantly remains parallel to a line connecting the pins P5 and P6 at fixed points, thereby allowing a direction of the transfer part 3 to also remain constant. Accordingly, when the sub-lever 2 is further oscillated so as to move beyond the guide rail 5 to thereby keep the parallelogrammic shapes of the parallel link bodies, the transfer part 3 resultantly moves to the other side of the guide rail 5 without changing its orientation.

[0033]

In this way, as far as the parallelogrammic shapes of the parallel link bodies are kept, the transfer part 3 is

allowed to continuously move as it is without changing the orientation, by which an object to be transferred can be transferred at high speed without the necessity of performing a slewing motion.

[0034]

When the main lever 1 and the sub-lever 2 are positioned on the guide rail 5, the parallel link bodies are on the dead point, and thus keeping the parallelogrammic shapes cannot be ensured. The present example, therefore, is so arranged that the permanent magnets M1 and M2, and the electromagnets E1 and E2 are relatively disposed, respectively, to serve as the shape control mechanism for controlling the shapes of the parallel link bodies when the parallel link bodies pass over the dead point.

[0035]

The operation of the shape control mechanism is now described taking the permanent magnet M1 and the electromagnet E1 for examples. The permanent magnet M1 has an N pole and an S pole, and the N pole is arranged, for example, as shown by (a) in Figure 3. On the other hand, the electromagnet E1 is formed of two coils EC1 and EC2 which may be ensured to be independently excited, and is disposed in such a way that a center of the electromagnet E1 aligns with a center of the guide rail 5. In a condition where the permanent magnet M1 moves in the directions shown by (a) in Figure 3, and the coils EC1 and EC2 are magnetized to provide N poles at the center and S poles at both ends, repulsive force

is produced then as a curved line shown by (b) in Figure 3. When a center of the permanent magnet M1 passes substantiallythecentersofthecoilsEC1andEC2,thedirection of force is inversed. Specifically, when the center of the permanent magnet M1 passes substantially the center of the coil EC1, magnetization is exerted, and when the center of the permanent magnet M1 passes substantially the center of the coil EC2, demagnetization is exerted. As a result, the permanentmagnetM1receivesarepulsiveforcewhentheparallel link body passes the dead point, so that the quadrangle of the parallel link body formed by connecting the pins P1, P2, P3 and P4 is kept in a shape of a parallelogram as shown by (a) in Figure 4.

[0036]

The same is applicable where the moving direction of the permanent magnet M is inversed.

[0037]

Similarly, with the shape control mechanism consisting of the permanent magnet M2 and the electromagnet E2, the quadrangle of the parallel link body formed by the pins P3, P4, P5 and P6 can be kept in a shape of a parallelogram by the same control.

[0038]

Depending on a layout, an object to be transferred may sometimes be required to be transferred with the front and rear of the transfer part 3 being reversed by 180°, for example. In this case, magnetization directions of the coils EC1 and

EC2 of the electromagnet E1 (or the electromagnet E2) are inversed, i.e. S poles are given at the centers and the N poles are given at both ends, so that an attractive force is produced when the parallel link body passes the dead point. As a result, the quadrangle of the parallel link body formed by connecting the pins P1, P2, P3 and P4 is not kept in a shape of a parallelogram, but instead the parallel links 1 and L1, which are opposed to each other, intersect with each other as shown by (b) in Figure 4 to enable in the end a slewing motion of the transfer part 3. In this connection, a slewing angle can be adjusted by appropriately selecting lengths of the main lever 1, the sub-lever 2, and the parallel links L1, L2 and L3 of the parallel link body.

[0039]

The same is applicable where the moving direction of the permanent magnet M is inversed.

[0040]

In this way, the shapes of the parallel link bodies can be controlled for passage over the dead point without using a gear, a belt, a rope or the like in a link mechanism. Thus, a transfer unit suitable for a clean room can be obtained, which has no worn part and has long duration of life without causing swirling of dust.

[0041]

So far, the transfer unit of the present invention has been described based on an embodiment , however, the present invention should not be limited to the arrangement of the

embodiment described above, but the arrangement can be changed to an extent not departing from the spirit of the invention by, for example, optionally using a mechanism having combinations of the electromagnets and the permanent magnets other than the ones in the example described above in the shape control mechanism for controlling the shapes of the parallel link bodies when the parallel link bodies pass the dead point. Besides being used being established on a fixed side, the transfer unit of the present invention can also be used being established on a side of a transfer apparatus of an object to be transferred.

[0042]

[Effect of the Invention]

According to the transfer unit of the present invention, since an arrangement is made such that an object to be transferred is transferred to the other side of the transfer unit without a slewing motion of the transfer unit, transfer time can be reduced. Further, since only the fulcrums in the forms of pins and serving as pivots are moved to transfer points, a high-degree of cleanliness can be maintained. Further, a guide rail located at a center of the transfer unit with no back-and-forth movement can limit source of dust to hardly cause swirling of dust. This can provide an easier measure for cleanliness comparing with the case of a telescopic arm and also can provide a measure for reducing weight and cost. Furthermore, owing to the link mechanism, both ends of the transfer unit are enabled to perform gradual speed up and

gradual stoppage in the drawing/withdrawing motion, thereby reducing shock and facilitating high-speed operation. The link mechanism can also provide a simplified structure, which is advantageous from the viewpoints of duration of life and maintenance. In this way, a transfer unit can be obtained at a low cost, which is suitable for performing high-speed and accurate transfer of large substrates such as for LCDs transferred at high speed in a clean room while suppressing swirling of dust.

[0043]

Further, an object to be transferred can be transferred with the transfer part being stably moved horizontally or being moved with a turn-over motion, by providing the shape control mechanism which is capable of selectively keeping or not keeping the shapes of the parallel link bodies, as required, when the parallel link bodies pass over the dead point.

[0044]

Furthermore, the shape control mechanism can have a structure which is simple, and easy to control with high reliability and no swirling of dust, by constructing the shape control mechanism with an electromagnet and a permanent magnet which is positioned relative to the electromagnet.

[0045]

Moreover, by providing the lifting unit for lifting up/down the entire frame including the transfer part, source of swirling dust can be limited so as to suppress swirling

of dust and contribute to further facilitating measures for cleanliness.

[Brief Description of the Drawings]

[Figure 1]

Figure 1 is a perspective view of an appearance of an embodiment of a transfer unit according to the present invention.

[Figure 2]

Figure 2 is s skeleton diagram of the transfer unit.

[Figure 3]

Figure 3 is an explanatory view showing a relation between an electromagnet and a permanent magnet.

[Figure 4]

Figure 4 shows operational states of the transfer unit, in which (a) shows a state of keeping the shape of a parallel link body, and (b) shows a state of not keeping the shape of the parallel link body.

[Figure 5]

Figure 5 is a plan view illustrating a conventional transfer unit.

[Figure 6]

Figure 6 illustrates an appearance of a conventional transfer unit.

[Description of Symbols]

1 main lever

2 sub-lever

3 transfer part

4 moving body

5 guide rail

6 frame

7 sub-leverdriveunit(driveunitforparallellinkbodies)

8 lifting unit

G object to be transferred

L1, L2 and L3 parallel links

E1 and E2 electromagnets (shape control mechanism)

M1 and M2 permanent magnets (shape control mechanism)

P1, P2, P3, P4, P5, P6 and P7 pins

X moving direction of the moving body

Y moving direction of the transfer part

Figure 3

#1 Center position of permanent magnets

#2 Repulsive force or attractive force